U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE YUMA AREA, ARIZONA-CALIFORNIA.

BY

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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LOCATION AND BOUNDARIES OF THE AREA.

The soil survey work of 1903 along the lower Colorado River, in the vicinity of Yuma, is a continuation of the work done by the Bureau in the winter of 1901–2. At that time a survey was made of what is locally known as Yuma Valley, which comprises the bottom lands from Yuma along the Arizona side of the river to the Mexican boundary line. The present work comprises all other lands on both sides of the river which it is possible to irrigate from the proposed Government canal to be diverted at some point near the Yuma dam site, as shown upon the map. Roughly speaking, the land that can be irrigated in this way all lies below the 200-foot contour line. Yuma is situated on the Arizona side of the Colorado River, about 20 miles from the Mexican boundary and about 21 miles from the dam and heading of the proposed canal.

FIG. 1.—Sketch map showing location of the Yuma area, Arizona-California.

Including the previous survey of 99 square miles, the Yuma area contains 217,408 acres, or about 340 square miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Below Yuma, in the Yuma Valley, quite a little progress has been made in agriculture, crops having been grown for some years, and the history of settlement and agricultural development of this area is given in some detail in the report made upon the work done in this valley in the spring of 1902 and published in the report on the field operations of the Bureau of Soils for that year.

On the valley lands covered by the present survey there is no irrigation of any extent. Only a little cultivation has been done, and in these instances crops have been grown wholly from the moisture left in the soil from the overflow. In this way small patches of corn, pumpkins, and other summer crops are being produced. Most of this cultivation has been done on the Indian reservation opposite Yuma on the California side of the river. A good many years ago there were a few alfalfa and grain farms along the Gila River toward the eastern end of the area surveyed. Water for irrigating these crops was taken from the Gila River by means of small ditches, but in 1891 the ditches were destroyed by flood, and since that time the farms have been abandoned.

On the mesa land, about a mile southwest of Yuma, there is an area of about 80 acres devoted to oranges, lemons, grape fruit, figs, grapes, and a few other deciduous fruits, water for irrigation being pumped from the Colorado River. Quite a few vegetables have also been grown on the same farm, which are ready for a very early market, and hence bring a fancy price. The fruit trees are in bearing and seem to do well. Oranges of good quality were being gathered in January, 1904. The orchard has not been well cared for, which gives it a sort of unkempt appearance. Better care would certainly greatly improve the quality of the fruit as well as the health of the trees. The experience gained, however, has been sufficient to demonstrate that citrus fruits can be made a success on the mesa lands.

CLIMATE.

The Yuma area is in an extremely arid belt. The rainfall is not only very light, but its time of occurrence is also very irregular, so that upon all lands not overflowed irrigation is the only source of moisture to be depended upon for all cultivated crops. The summers are long and very hot, while the winters can hardly be called such at all. The maximum daily temperature in summer often ranges from 112° to 120° for weeks at a time, although the nights are usually cool enough to be comfortable. The winter nights, especially in the valley, are occasionally quite cold, ice often forming, but the days are

most delightful. Very seldom is a cloud seen. Many of the people live almost entirely out of doors, and suffer very little discomfort on account of the weather. The mesa land, situated to the south and east of the valley lands along the river, has a slightly different climate from these valley lands. Upon this mesa the nights are not so cold, and frost occurs less often. Here orange and other citrus trees thrive, and suffer but little from cold weather.

Appended is a table compiled from records of the Weather Bureau, showing the temperature and rainfall at Yuma. There is no other station in the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Yuma.		Month.	Yuma.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° *F.*	*Inches.*		° *F.*	*Inches.*
January	53.9	0.42	August	91.6	0.35
February	59.0	.51	September	84.2	.15
March	65.1	.26	October	72.5	.28
April	70.5	.07	November	62.7	.29
May	77.8	.04	December	57.3	.46
June	84.8	.00	Year	72.6	2.97
July	91.5	.14			

PHYSIOGRAPHY AND GEOLOGY.

The valley lands immediately along the river are broken only by the local occurrence of sand dunes, gullies, lagoons, or old river beds. These minor departures from grade in some instances will make leveling for irrigation quite expensive, but in very few instances are they sufficient to make economical leveling impossible. Skirting the valley lands on the east and south is a large area of mesa lands which for the most part is comparatively level. This mesa proper rises from 65 to 70 feet as an abrupt bluff along the valley lands. In the eastern part of the area, however, there is quite a little mesa land that is but a few feet higher than the valley.

The valley is formed almost wholly from sedimentary deposits left by the river as it has cut through the mesa to form the valley. The general formation is a great bed of sand overlain and interstratified with layers of finer material deposited by the river as it has shifted its course from one side of the valley to the other. Except immediately along the foothills or mesa that surrounds the valley, the soils are not traceable to the rock whence they came, as the Colorado has a great number of tributaries which drain a vast territory, and any one of these tributaries may be chiefly responsible

at different flood seasons for the sediment carried by this lower part of the stream. The mesa is an old coastal plain, and that part of it mapped was once near the beach. It is all comparatively level, except for a strip about one-fourth of a mile wide along the bluff line which erosion has made quite rough.

The area is dissected by the Colorado River, the largest stream in the Southwest. The Gila River, an intermittent stream, flows into the Colorado at the town of Yuma.

Gila Valley forms the greater part of the bottom lands of the valley proper. Much of these lands is overflowed.

The northern part of the area is bounded on each side by granitic hills, while farther to the south the eastern side of the mesa land mapped is bounded by only a slight rise in the plain, the soils remaining the same to the eastward. Colorado River, where it forms the boundary between Lower California and Arizona, bounds the area on the west.

SOILS.

The soils of the area mapped are distinctly of two series—valley soils proper, or those alluvial soils formed from deposits of the Colorado and Gila rivers, and mesa soils, or those which formed the coastal plain along the Gulf when it extended much farther inland than at present. The river valleys are underlain at varying depths by sand, which makes the drainage in the soil itself very good. This sand is in places quite coarse, but the greater part is medium to fine in texture and has the characteristics of quicksand. When this fine sand is found on the surface it forms the Imperial fine sandy loam.

In the valley the following six types of soil were recognized and mapped: Imperial sand, Imperial sandy loam, Imperial fine sandy loam, Imperial silt loam, Imperial loam, and Salt River adobe. The mesa is made up almost entirely of one type of soil, a rather coarse sand, that in places is cemented together by a small amount of lime. Along the washes in the low mesa land to the east of the northern part of the area is found a very loose, incoherent, gravelly sand which was mapped as Fresno gravelly sand.

Along the edge of the mesa there is a strip of land of varying width which, because of its roughness, was mapped as Rough stony land. Other small areas throughout the district that were evidently too rough to be leveled for irrigation were also thrown in this class so that, in all, the soil map accompanying this report shows in colors nine distinct soil types.

The following table gives the actual and relative extent of each of these types:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Yuma sand	94,400	43.5	Rough stony land	6,080	2.9
Imperial fine sandy loam	38,848	17.8	Fresno gravelly sand	4,160	1.9
Imperial loam	24,384	11.2	Salt River adobe	4,096	1.9
Imperial sandy loam	18,496	8.5	Total	217,408	
Imperial sand	14,272	6.4			
Imperial silt loam	12,672	5.9			

IMPERIAL SAND.

The Imperial sand occupies about 22 square miles, or 6.4 per cent of the area mapped. It is a loose, incoherent, reddish-brown fine sand, usually 5 or 6 feet or more in depth. However, where it occurs in places near the mesa it is but 3 or 4 feet in depth, and is underlain by a sandy loam or loam, the heavier material representing the deposit from the river when the overflow reached to the mesa.

This soil is found in rather large areas throughout the valleys of the Gila and Colorado. Where it has been deposited by the rivers, it is made up of the largest particles which they carry. Areas along the mesa have been formed by the washing down of sand from the mesa upon the valley below. In nearly all cases the areas show some minor surface irregularities, such as dunes or washes, caused, respectively, by the wind or overflow waters acting upon its incoherent soil particles.

The Imperial sand is in all cases of such texture as to be well drained, water passing through it very rapidly. All areas above present overflow are well drained at present, but some of the low-lying areas along the river now subject to overflow have the water table close enough to the surface to make artificial drainage desirable for the growing of deep-rooted crops.

Very little of the Imperial sand now carries sufficient alkali to interfere with the growing of any of the ordinary crops. Along the mesa lands, however, where the subsoil at 3 or 4 feet is rather heavy, there is now in places quite a high percentage of alkali in the subsoil. This, however, with careful irrigation, should be leached out, and should prove of very little moment so far as its effects on growing crops are concerned.

None of this soil has been cultivated in the part of the district mapped in this survey, but below Yuma, along the Colorado River, quite large tracts have been used for some years in the growing of alfalfa, which crop does remarkably well. Barley, wheat, melons, vines, deciduous fruits, berries, and all truck crops should also do well. It is generally believed that the valley proper is too cold to grow citrus fruits, but if experience should demonstrate that these trees can withstand the low temperatures sometimes experienced in

the valley, then the Imperial sand, because of its freedom from alkali and ease of cultivation, should prove to be well adapted to these fruits.

The following table gives the results of mechanical analysis of a sample of this soil type:

Mechanical analysis of Imperial sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10280	1st 40 sec. 12, T. 7 S., R. 22 W.	Fine sand, 0 to 72 inches	0.00	Tr.	1.20	42.20	38.00	15.00	3.58

IMPERIAL SANDY LOAM.

The Imperial sandy loam is a loose, friable, reddish brown sandy loam of good texture. It will be easy to cultivate, and will require but little cultivation to maintain surface mulch and good tilth. It is usually underlain by sand of the same texture as the Imperial sand at a depth of from 3 to 4 feet, but in some instances there is an intervening stratum of loam 2 or 3 feet in thickness. The sand subsoil extends to undetermined depths.

In the area mapped the Imperial sandy loam is found chiefly in the Gila Valley east of Yuma, although small areas occur elsewhere. It is usually comparatively level, except for very small dunes about the base of small bushes or trees, but on the south side of the Gila River there is a district that is quite rough. This roughness was caused by the scouring and washing of the Gila River during the flood of 1891, at which time much country was overflowed that is not subject to ordinary annual overflows, this flood being the only one to cover these lands within the memory of the oldest inhabitants. Some of this land will be expensive to level, and can be brought under cultivation only after a considerable outlay of money.

Being underlain by sand at a few feet at most, all this soil is well drained, and only in exceptional cases should crops ever suffer on account of poor drainage. A canal carried through or just above low-lying areas might swamp a portion of it, but in such cases a few drains would be sufficient to carry off all surplus water and permanently to insure good drainage. The soil has been formed principally by a direct deposition of sediment from the rivers, but along the mesa areas are formed by an admixture of sand washed in from the mesa and smaller particles deposited from the river.

In some parts near the overflow lands and along the mesa the sandy loam contains alkali. When these alkaline areas occur near the overflow lands, they are caused by the water table, for a part of the year at least, being so near the surface as to make possible the evaporation of a great deal of water from the surface of the soil, leaving behind the salts contained in this water. In this way, in time, quite an accumulation of alkali results. Along the mesa the alkali has been caused by seepage from the mesa and a like evaporation from the surface.

No crops are now being grown in the valleys; but several years ago, before all the water from the Gila River was appropriated for irrigation farther upstream, quite a little land on each side of the river was in alfalfa and grain. The flood of 1891 destroyed the ditches supplying these ranches, however, and so much water was appropriated for use above that no attempts have since been made to bring these lands under cultivation. For alfalfa, fruits, and vegetables, or almost any crop suitable to the climate, it should prove a good soil.

The following table gives the results of mechanical analyses of this type:

Mechanical analyses of Imperial sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10272	SW. cor. 6th 40 sec. 17, T. 8 S., R. 21 W.	Sandy loam, 0 to 48 inches.	0.20	1.38	4.00	41.02	32.70	10.20	10.30
10273	NE. cor. 7th 40 sec. 9, T. 8 S., R. 21 W.	Sandy loam, 0 to 60 inches.	.20	.70	.90	15.80	29.10	38.48	14.90
10274	S. cen. 5th 40 sec. 4, T. 8 S., R. 21 W.	Sandy loam, 0 to 72 inches.	3.10	6.96	5.60	23.28	30.20	14.40	16.40
10271	SW. cor. 14th 40 sec. 19, T. 8 S., R. 21 W.	Loam, 0 to 48 inches	.00	Tr.	.48	8.96	28.70	44.50	17.40
10279	SE. cor. 1st 40 sec. 20, T. 8 S., R. 21 W.	Loam, 0 to 72 inches	.00	.10	.20	8.86	31.20	41.40	18.20
10278	10th 40 sec. 28, T. 8 S., R. 22 W.	Loam, 0 to 12 inches	.00	.54	.96	7.72	9.48	59.20	22.10

IMPERIAL FINE SANDY LOAM.[a]

The Imperial fine sandy loam is a fine to very fine sandy loam. The particles are nearly all of uniform size, making a soil of high capillary power and one through which water moves not only long

[a] This soil was mapped under the name Gila fine sandy loam in the survey made around Yuma in 1902.

distances, but also with great rapidity. It will be easily cultivated, and will be in good tilth for a long time after each cultivation. The surface soil is from 3 to 20 feet deep, and is nearly always underlain by a coarser sand. In some instances, however, the areas of shallower soil have a stratum of heavier material between the surface covering of fine sandy loam and the sand beneath.

The Imperial fine sandy loam is found in long, narrow strips along the Colorado River and farther out in the bottoms, and in large areas in the valley between the Gila and the Colorado, and south of the Gila in its own valley. It is usually quite smooth, and will require but little leveling to prepare it for irrigation. Over most of it the greatest expense in preparing the land for cultivation will be for clearing, as it is usually covered with a dense growth of cottonwood, willow, or arrow weed. A notable exception to this, however, is the large area, strongly impregnated with alkali, situated in the joint valley of the Gila and the Colorado.

The sandy subsoil in this type insures good drainage if there be an outlet for the ground water, and with such an outlet frequent flooding will prevent a surface accumulation of alkali.

The Imperial fine sandy loam is composed of sediments deposited when the rivers spread out in their annual flood. As the river overflows its banks it is checked by timber, bushes, etc., and the coarser particles in suspension are dropped, forming this fine sandy loam, the lighter or smaller particles being carried farther inland and deposited in comparatively still water. In this way the land near the river is built up faster than that farther back, which ultimately results in the river cutting through its bank and seeking a lower bed. Thus the various areas of the Imperial fine sandy loam have been formed as the river has shifted about from channel to channel, and this is why the areas are slightly higher than the surrounding areas of loam or silt loam.

At some time nearly all the valley has had a high water table. Water moves through this soil with such rapidity that with this high water table it would quickly be filled with alkali, and nearly all the areas not now subject to annual overflow and leaching carry more or less of these injurious salts, which have been concentrated through evaporation at the surface. Where the water table has stood for some years close to the surface, and no surface flooding has taken place, an accumulation of as much as 3 per cent in the surface foot is not uncommon. A few heavy surface floodings, followed by cultivation to prevent evaporation, should greatly improve these lands, however, and, on the whole, though some areas are now shown in the " 1 to 3 per cent " grade on the alkali map, this condition, as affecting the ultimate value of the land, is not a very serious one. One year's heavy flooding should suffice to reclaim the

shallower areas with a sand subsoil, and all areas may be quickly reclaimed, provided there be drainage sufficient to carry off the ground water. The same properties in the soil that have favored the rapid accumulation of alkali will aid in its rapid removal.

This soil is an exceptionally good one for all crops suitable to the climate, and especially for alfalfa. It is so deep and of such excellent texture that it affords a deep root field, and offers the minimum resistance to the extension of the tiny root hairs so essential to the perfect growth of this valuable forage plant. Because of its location along the bottoms, many tree fruits that can only be grown in very deep soil will no doubt suffer from the high water table, but for all shallow-rooted vines, fruits, and vegetables no better soil is found in the valley.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Imperial fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10258	3/8 N. of SE. cor. sec. 10, T. 16 S., R. 23 W.	Fine sandy loam, 0 to 72 inches.	0.00	0.26	0.44	18.30	56.22	21.40	3.38
10247	NW. cor. 4th 40 sec. 26, T. 16 S., R. 22 W.	Fine sandy loam, 0 to 72 inches.	.00	.16	.18	12.90	46.44	33.20	7.10
10248	1/8 S. of NW. cor. sec. 31, T. 6 S., R. 21 W.	Fine sandy loam, 0 to 72 inches.	.10	.40	.20	2.22	33.80	55.50	7.70
10240	NW. cor. 2d 40 sec. 6, T. 7 S., R. 21 W.	Silty loam, 0 to 36 inches.	.00	Tr.	.60	3.10	21.60	65.90	8.62
10226	5/8 SW. of NE. cor. sec. 8, T. 8 S., R. 22 W.	Silty loam, 0 to 60 inches.	Tr.	.20	.20	4.48	19.38	60.50	15.30
10254	3/8 NW. of SE. cor. sec. 16, T. 8 S., R. 22 W	Silty loam, 0 to 72 inches.	.00	.00	Tr.	4.40	12.50	61.70	21.12
10225	NE. cor. 5th 40 sec. 20, T. 8 S., R. 22 W.	Medium sand, 36 to 72 inches.	.00	.70	9.48	61.20	16.40	8.58	3.60
10233	Subsoil of 10232	Sandy loam, 48 to 72 inches.	7.18	11.30	9.00	22.26	23.46	15.40	11.28
10229	Subsoil of 10228	Brown loam, 36 to 72 inches.	.00	.00	.10	4.30	7.54	44.00	44.00

IMPERIAL SILT LOAM.[a]

The Imperial silt loam is composed of the next grade of material finer than that forming the Imperial fine sandy loam. Like the fine sandy loam, it consists of particles of very uniform size. It is a gray

[a] This soil mapped under the name Santiago silt loam in the survey made around Yuma in 1902.

to brown, rather heavy, loamy soil, from 12 to 30 inches deep, usually underlain by sand, but in rare instances by loam or even clay. It also is found principally along the Gila or Colorado River, on lands at present overflowed, where it occurs only as a surface covering for the other soils. Any shifting or changing in the river channels would no doubt change the boundaries of the areas outlined. It occupies low places, such as the beds of former river channels or large depressions where water may drain off, but where in times of overflow it has very little, if any, current. The surface of the various areas is always comparatively level, but usually all this type of soil is below the surrounding lighter soils, and as the areas are, as a rule, long, narrow strips, some expense will be necessary to bring them under irrigation.

The silt loam is and will continue to be the most poorly drained type in the area. Over most of the valley the water table at the time of examination was not close enough to the surface to injure grain or other comparatively shallow-rooted crops, but if the country were leveed, as would have to be done to grow any but overflow crops, this soil would be the first to suffer in time of high water in the river from the rising water table. Being underlain by a lighter sandy material, the water would rise rapidly in the subsoil, while the low-lying position of the areas would make them the first to become swampy.

Like most of the soils of the valley, this type is directly traceable to the sediment of the Colorado or Gila River. Both rivers carry a great amount of sediment in overflow times, much of which is deposited upon the bottom lands as soil. The silt loam is the sediment deposited after the moving waters have been robbed of their fine sand to form the Imperial fine sandy loam.

When it occurs in large areas the Imperial silt loam is often free from alkali, but the long, narrow strips often carry appreciable quantities, and sometimes quite a high percentage. This condition is caused by the high water table, either immediately after overflow or throughout the year.

In the areas mapped almost no crops have been grown on this soil type, but when the coarse sand does not approach too near the surface it should prove an excellent soil for all summer overflow crops, such as Kafir, Egyptian, and Indian corn, Milo maize, millet, sorghum, etc. Garden vegetables, melons, and pumpkins could all be grown from this overflow. Much of this soil now lying idle and supporting only useless willows might thus be made to grow valuable crops from the overflow alone. When diked and subjected to perennial irrigation, with drainage to carry off the surplus of ground water during high stages of the river, almost any crop suitable to the climate could be

grown. It is a very rich soil and easily cultivated, so that it lends itself readily to the growing of special crops under a high state of cultivation. It is on a similar soil in Orange County, Cal., that most of the celery for which that county is noted is grown, while it is one of the most important bean soils of Ventura County, in the same State.[a]

The following table gives mechanical analyses of this type:

Mechanical analyses of Imperial silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10285	S. cen. 9th 40 sec. 8, T. 8 S., R 21 W.	Heavy silty loam, 0 to 12 inches.	0.26	0.60	0.52	4.68	22.40	48.28	23.42
10289	SE. cor. 12th 40 sec. 18, T. 7 S., R. 22 W.	Silty loam, 0 to 36 inches.	.00	.24	.20	1.54	8.12	63.20	26.68
10290	NW. cor. 1st 40 sec. 26, T. 8 S., R. 23 W.	Silty loam, 0 to 72 inches.	.00	.00	.00	3.10	12.90	54.30	29.40
10283	Cen. SW. ¼ 14th 40 sec. 6, T. 8 S., R. 22 W.	Heavy silty loam, 0 to 18 inches.	.00	.58	.60	2.40	4.40	54.60	37.30
10287	16th 40 sec. 12, T. 7 S., R. 22 W.	Clay loam, 0 to 14 inches.	Tr.	.30	.34	1.92	3.64	53.90	39.80
10284	Subsoil of 10283	Sand, 18 to 72 inches	.22	3.70	22.90	58.90	11.74	1.72	.76
10286	Subsoil of 10285	Fine sand, 36 to 72 inches.	.00	.18	.78	50.90	34.46	10.40	3.00

IMPERIAL LOAM.

The Imperial loam is a sticky, plastic, rather heavy, difficultly cultivable, chocolate-brown loam, composed of finely divided particles of mineral matter, and often a liberal addition of organic matter. In the districts mapped this season the surface soil ranges from 3 to 6 feet deep, and is usually underlain by a sand, although in some cases clay is found between the loam and the sand beneath.

The Imperial loam is pretty well distributed throughout the bottom lands, but the largest areas are on the south side of the Gila River, along and below the mesa line that divides the high plateau back of Yuma from the bottoms proper. It is nearly always level, and requires but little work to prepare for irrigation. Most of it is above present overflow, and for this reason is quite well drained.

This soil, too, owes its existence to the Colorado and Gila rivers. It is the same soil found so extensively below Yuma on lands at present overflowed, and is the principal soil of the Imperial country

[a] See Field Operations of the Bureau of Soils, 1900.

in California. All these areas have been deposited directly from the waters of the rivers.

Nearly all the Imperial loam contains alkali. The percentage varies from about 0.20 per cent to more than 3 per cent. Because of its present condition as regards these injurious salts, its depth, and the frequent occurrence of the heavy subsoil, injury to crops from alkali is more to be feared in this soil than in any other in the area. Under careful management, however, it should prove a very productive and valuable soil for the cereals and such summer annuals as Kafir, Egyptian, and Indian corn, millet, sorghum, and in fact all crops not requiring intertillage. Alfalfa does well if not pastured, but pasturing tends so to pack the soil as soon to kill the plants.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Imperial loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10264	⅛ NW. of SE. cor. sec. 35, T. 8 S., R. 22 W.	Loam, 0 to 24 inches	0.16	1.68	3.06	15.30	19.26	22.90	37.68
10263	SW. cor. 14th 40 sec. 32, T. 8 S., R. 22 W.	Brown friable clay loam, 0 to 72 inches.	.00	.20	.36	2.48	11.60	42.60	42.68
10261	3d 40 sec. 34, T. 8 S., R. 22 W.	Heavy clay loam, 48 to 72 inches.	.00	.00	.08	.48	4.96	61.26	33.20

SALT RIVER ADOBE.

The Salt River adobe is a very heavy dark-brown to black clay loam, from 1 to 3 feet deep, sticky, plastic, and difficult to cultivate, and underlain by fine sandy loam or fine sand. When the water subsides and the surface is exposed to the hot sun, great cracks, 2 to 4 inches wide, cut the surface in every direction, often extending into the soil to a depth of 2 feet or more. These cracks divide the soil into blocks from 1 to 2 feet in diameter. As the soil dries further and is subjected to weathering agencies, these blocks weather down into rounded elevations with numberless small cracks crossing them in all directions.

Only very small areas of this soil are found in the Yuma area, and these are nearly all on overflowed land in the immediate vicininty of Yuma or regions influenced by sediment of the Gila. The surface is

smooth, level, and much lower than that of the surrounding soils. As a rule this soil occurs along the sloughs and old river beds, where water may often be found several months after the subsidence of the Colorado. It is composed of fine alluvial sediments, and since it is found principally in that part of the valley affected by the Gila, and the same soil is found along its tributaries farther east in Arizona, it is fair to presume it is here built up from the sediment of this stream.

Only part of this soil contains alkali, but if it were not for the annual overflow its low-lying position and consequent poor drainage would soon result in such an accumulation of these injurious salts that crops could not be grown. Irrigation on adjoining higher lands would in most cases soon swamp it. No crops have been grown upon it, but with adequate drainage precautions, corn, sorghum, the nonsaccharine sorghums, cereals, and other annual crops not requiring intertillage would do well. Its heavy, sticky properties would seem to make the growing of crops requiring intertillage of doubtful profit.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Salt River adobe.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
10291	S. of cen. 12th 40, sec. 23, T. 16 S., R. 22 E.	Clay to clay loam, 0 to 42 inches.	Tr.	0.12	0.20	3.80	12.78	42.30	41.00
10292	Subsoil of 10291	Yellow fine sand, 42 to 72 inches.	.00	.00	.70	80.40	16.28	.40	1.72

YUMA SAND.

The Yuma sand is a rather compact coarse to medium sand, containing sufficient finer material to give it a slightly loamy character. When dry the soil has the appearance of sand, but upon irrigation, as, for instance, at Blaisdell Heights, it becomes almost a sandy loam. It is underlain at a depth of from 2 to 6 feet by a succession of layers in which the soil particles are slightly cemented, the binding material being calcium carbonate, nodules of which are also found in the subsoil. A little gravel is encountered here and there, being more noticeable near the margin of the mesa, where the washing

out of the finer material has left behind the gravel originally distributed through several feet of material. The subsoil to a great depth is of the same sandy nature as the surface. In a well recently bored on the mesa about 2 miles south of Yuma the same sandy material was found to extend to a depth of 70 feet, where clay was encountered. Along the ridge of the mesa, strata of heavier material from 1 to 3 or 4 feet thick outcrop in various places.

The Yuma sand is found wholly on the mesa lands south of the Gila Valley and east of the Colorado Valley proper below Yuma. It is, in general, practically level and smooth, but where the texture is finer small dunes are found. These are rather low and broad, and will be neither difficult nor expensive to level for irrigation. The soil will always be well drained.

This mesa land, where the railroad cut at Yuma exposes it to a depth of 30 to 50 feet, and along the bluff skirting the valley, shows imperfect stratification, which might be due either to action along an old beach line or to delta deposits. The large uniform tract of coarse sandy soil, however, indicates a deposit in water near a beach line, so that in all likelihood this soil was formed when the Gulf extended several miles above Yuma.

Nearly all the mesa soil contains a small amount of alkali, ranging from a trace to nearly 0.20 per cent. The open, porous nature of the soil and its high-lying position, however, make this amount of no danger, provided occasional floodings be employed to wash the salts down into the subdrainage waters.

Oranges and other citrus fruits, figs, grapes, garden vegetables, and melons have been grown on this soil at the Blaisdell farm, south of Yuma, and all with success. The orange grove does not compare with the southern California groves, either in general appearance or quality of fruit, but such could hardly be expected from the scant care given it. The orchard has a general unkempt appearance and certainly has not been given proper treatment. Under more careful and scientific management oranges should do well. Lemons might do well farther out on the mesa, but near the valley frosts would possibly injure them. During the winter of 1901–2, as the writer observed, nearly all the leaves of the orange grove had been so badly frosted that they were dropping. Vegetables and early fruits, berries, melons, etc., should be a paying crop on these lands, as the mesa is so much warmer than the valley that they ripen earlier, and all crops are a month or so earlier here than in southern California. Alfalfa might do well also, but other crops will no doubt prove more valuable.

The following table gives the results of mechanical analyses of typical samples of the Yuma sand:

Mechanical analyses of Yuma sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10220	Cen. sec. 36, T. 11 S., R. 23 W.	Red medium sand, 0 to 12 inches.	0.20	5.36	13.46	57.80	21.20	1.20	0.68
10223	NW. cor. of 12th 40 sec. 11, T. 9 S., R. 23 W.	Fine sand, 0 to 72 inches.	.70	1.90	9.60	69.40	12.36	3.20	2.90
10221	1/16 W. of cen. sec. 14, T. 9 S., R. 23 W.	Medium sand, 0 to 48 inches.	3.00	13.88	23.90	38.70	13.54	3.34	3.50

FRESNO GRAVELLY SAND.

The Fresno gravelly sand is a loose, incoherent sand 6 feet or more in depth, containing gravel. The interstitial material varies from a light-brown to an almost pure-white quartz sand, and the pebbles range in size from coarse sand to 3 or 4 inches in diameter.

This type of soil is found along the eastern edge of the area, north of Gila River to the northern limits of the sheet, and along the western part of the area that is flanked by hills, occupying the floor of the small washes and forming a part of the terrace above the bottom lands proper. It is generally of fairly smooth surface, but may have a rather steep slope. Nearly all of it can be irrigated with not too great an expenditure of money, provided the canal is carried above it. The greater part of it, however, lies quite high, and to run a canal at such a level as would make irrigation convenient would mean great expense for excavation.

This soil is the wash from hills along the valley, and has been formed by deposition from small streams or from the waters of heavy downpours acting along the sides of the hills.

The Fresno gravelly sand is all well drained and free from alkali salts. No crops have been grown, but upon irrigation tree fruits, grapes, and other deep-rooted trees should do well. Grain, alfalfa, and the other common field crops might do fairly well, yet the porous nature of the soil would require the use of so much water as to render their production of doubtful profit. The type as a whole is especially adapted to the fruits suited to the climate.

The following table gives the results of a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Fresno gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10222	5th 40 sec. 8, T. 7 S., R. 21 W.	Coarse sand, 0 to 72 inches.	2.40	13.50	26.60	33.88	15.82	4.90	2.80

ROUGH STONY LAND.

The rough, uncultivable portion of the area includes all very rough lands surrounded by cultivable soil. The soil may vary in texture from bare rock outcrop to sand. Several small hills of coarsely crystalline granite on the mesa southeast of Yuma, other hills of a sandy loam east of the northern part of the area, and the rough, weathered bluff line along the mesa constitute about all the lands too rough for cultivation. Of these the mesa line may, under intensive cultivation, eventually become valuable as terraced tree lands. The soil along this bluff is a gravelly sandy loam, in some cases carrying a low percentage of alkali.

HARDPAN.

The soil of the mesa land above Yuma contains, at a depth ranging from 2 to 6 feet, successive layers of material that somewhat resembles hardpan. These layers are caused by a slight cementing of the soil particles with calcium carbonate. Calcium carbonate nodules also occur in some of these strata, and where this is the case the material somewhat resembles the hardpan of the Salt River Valley, though much less coherent and not so thick in any one stratum. In fact, these strata are not a hardpan in the true sense of the word and they should entirely disappear upon irrigation.

If it were not for the abundance of gypsum in the irrigation water of the river the breaking up of this so-called hardpan would no doubt result in the formation of sodium carbonate, or black alkali, which, in the growing of fruits with furrow irrigation, would no doubt accumulate at the surface. The presence of gypsum, however, will prevent the black alkali existing as such for any length of time.

In the bottom lands there is no trace of any hardpan, nor of any slightly indurated strata, such as those described as occurring in the uplands.

WATER SUPPLY FOR IRRIGATION.

None of the lands covered by the present survey are irrigated, except the small tract on Blaisdell Heights, water for which is pumped from the Colorado. All of the water for irrigation of the area examined will come from the Colorado, the Gila being an intermittent stream and hardly to be depended upon as a source of supply. The Colorado here is a large stream of muddy, silt-laden water. It has its source in high, snow-clad mountains, so that the maximum amount of water comes down during the hot summer months. From June to August the Colorado is a raging torrent, overflowing its banks and cutting and changing its channel. The overflow area in the tract surveyed begins only a few miles above Yuma and gradually widens till near the point where the Colorado leaves the United States. All the bottom lands proper are overflowed. During these months vast quantities of water flow into the Gulf and are lost. The normal flow of the river, as shown by official measurements, will no doubt, suffice to irrigate all lands of this lower delta part of the country if no great appropriations take place above. The greatest flow comes during the season when the greatest amount of water is needed, so that if the water is used for these lands alone little or no storage will be necessary.

The quality of this irrigation water is good. A number of chemical analyses show that on an average it contains about 87 parts of soluble matter per 100,000 of water, and about 31 per cent of the total salts is gypsum, which is beneficial to crops. No fear need be had in using such water if ordinary precautions be taken to prevent continuous subirrigation, and an occasional flooding given those lands not flooded in the ordinary course of irrigation. The water of the Colorado contains a great deal of fertility, or plant food, both in suspension and in solution, as shown by a series of analyses extending through the year, made by Prof. R. H. Forbes, director of the Arizona experiment station. These analyses show the water of this river to be as rich, if not richer, than that of the world-famed Nile. If a system of canals can be made upon such a grade that the sediment will reach the cultivated fields, the productivity of the soil should be practically inexhaustible, making possible the almost continuous growing of any strong feeding crop without diminution in yield.

The following table, showing the composition of the waters of the

Colorado River, is taken from Bulletin No. 44 of the Arizona agricultural experiment station, by Prof. R. H. Forbes:

Composition of the waters of the Colorado River.

PARTIAL ANALYSIS.

Samples taken at Yuma, Ariz.	Low winter waters, Jan. 10–Mar. 26, 1900.	Rising summer waters due to melting snows, etc., Mar. 27–Apr. 31.	High summer waters due to melting snows, etc., May 1–June 29.	Low waters after melting of snows, June 30–Aug. 26.	Summer waters affected by local floods, Aug. 27–Oct. 1.	Summer flood waters from Arizona, Oct. 2–Nov. 19.	Low winter waters, Nov. 20–Jan. 24, 1901.
Silt, per cent by weight	0.0625	0.1122	0.374	0.122	0.278	0.933	0.1513
Soluble solids, parts in 100,000	92.95	67.4	32.16	36.1	71.4	104.5	87.1
Containing:							
Chlorine, stated as common salt, NaCl	33.76	22.1	7.4	11.45	25.9	28.2	30.4
Alkalinity, stated as sodium carbonate, Na_2CO_3	----	----	----	----	----	----	----
Permanent hardness, stated as calcium sulphate, $CaSO_4$	14.03	16.28	6.06	5.03	11.22	27.35	12.22
Nitrogen, parts in 100,000:							
Total nitrogen in silt and water	1.52	1.71	2.43	1.25	2.71	7.33	2.26
Nitrogen in nitrates	1.15	.66	.62	.64	.67	.99	.80
Nitrogen in nitrites	Traces.	Traces.	Traces.	Traces.	Traces.	Traces.	Traces.

COMPLETE ANALYSIS OF SOLUBLE SALTS, STATED BY IONS. PARTS IN 100,000 OF WATER.

Sodium, Na	18.98	15.34	5.49	7.63	14.63	18.17	15.95
Potassium, K	1.07	2.08	1.02	1.29	1.77	2.13	1.22
Calcium, Ca	7.49	4.86	4.23	4.57	7.66	12.45	9.17
Magnesium, Mg	3.14	2.00	1.15	1.21	2.21	2.80	2.80
Chlorine, Cl	20.50	13.88	4.48	6.91	15.76	17.45	18.06
Sulphuric, SO_4	26.10	19.38	7.16	7.62	19.68	35.64	23.81
Carbonic, CO_3	7.35	8.36	7.21	7.73	9.95	12.18	10.66
Silicic, SiO_3	4.59	2.10	2.13	3.28	2.34	2.23	2.08

COMPLETE ANALYSIS OF SOLUBLE SALTS, CALCULATED TO COMPOUNDS. PARTS IN 100,000 OF WATER.

Sodium carbonate, Na_2CO_3	----	----	----	----	----	----	----
Sodium silicate, Na_2SiO_3	7.36	3.37	3.41	5.26	3.75	3.58	3.34
Sodium chloride, NaCl	33.83	22.90	7.40	11.40	26.00	28.80	29.80
Sodium sulphate, Na_2SO_4	8.89	15.58	3.97	3.58	9.19	16.89	9.10
Potassium sulphate. K_2SO_4	2.38	4.64	2.28	2.87	3.94	4.75	2.72
Magnesium sulphate, $MgSO_4$	1.01	----	----	----	----	----	----
Magnesium carbonate, $MgCO_3$	10.29	7.00	4.03	4.24	7.74	9.80	9.80
Calcium sulphate, $CaSo_4$	25.46	8.91	4.56	5.13	16.01	30.60	22.89
Calcium carbonate, $CaCO_3$	----	5.60	7.22	7.65	7.38	8.63	6.10

UNDERGROUND AND SEEPAGE WATERS.

All of the valley lands mapped have water underlying at a depth of from 3 to 25 feet. Seldom is the depth as great as 25 feet, except on the higher portions immediately along the mesa. This underground water varies greatly in character, ranging from practically the same composition as the river water to strongly brackish. This variance in amount of soluble matter is due to the spotted nature of the soil, salts in the water being in nearly all cases traceable to the alkaline areas of soil. By sinking a few prospect holes, which can be rapidly done, good water for domestic use can be had on nearly any 40-acre tract in the bottoms.

During the period covered by the survey (October 1 to December 31, 1903) very little of the land not subject to overflow or surrounded by overflow lands had water less than 10 feet from the surface. On much of the overflowed lands, however, the water was within 3 or 4 feet of the surface. In order to control the irrigation these lands would have to be diked, which, during the overflow season, would raise the height of the water in the confined stream and thus subject this ground water to a greater head than it now has, and raise it even nearer the surface. For these overflowed lands, if diked, and for some of the alkali lands a drainage system is necessary.

ALKALI IN SOILS.

A considerable part of the lands surveyed carries an appreciable quantity of alkali. The lands so affected are found principally in three characteristic situations: Along the outer edge of the area subject to annual overflow; on the high ridges within the overflowed district, but not actually covered by water; and in a narrow strip immediately below the mesa. Other isolated patches of alkali land occur, but the above-mentioned areas include about all those of any magnitude.

The alkali found just above overflow and on the small areas surrounded by water, but not actually covered, comes principally from the salts carried in solution by the water, but partly from the decomposition of the soil itself. Its accumulation is all directly due to the high water table maintained by the standing of water upon the near-by flooded area. Evaporation takes place from the surface very rapidly in this hot country, and when the water approaches so close to the surface that capillarity makes connection between the water and the surface the amount evaporated is great, the salts contained in the water being left behind largely at the surface, the point of greatest evaporation. The rainfall here is inappreciable, so that there is nothing to wash this accumulation down into the subdrainage, unless artificial watering occur, as in

flooding in irrigation, or by natural overflow covering the surface. After successive years of this evaporation enough salt is accumulated to injure or prevent the growth of useful plants.

Much of the lands now subjected to overflow has a high water table the year around, so that during the interval between floods there is quite an accumulation of salts at the surface. Each successive overflow washes the salt out and leaves the soil, immediately after the subsidence of the water, practically free from injurious salts. Thus these lands may be said to be intermittently alkaline, and as long as the present order of things is maintained their condition will not be very bad.

The alkali at the foot of the mesa has been caused by the subirrigation of these areas by the slight seepage from the mesa lands, the difference in elevation between the mesa and the bottoms below being from 65 to 80 feet. This mesa soil all contains a small quantity of alkali, so that water seepage from it would be slightly impregnated. Its evaporation from the surface would leave salts behind and account for the accumulation here just as the accumulation has occurred near the overflow lands.

A great number of analyses have been made of the soils found upon the delta of the Colorado and the valleys along this river, to determine the chemical composition of the soluble salts found. Appended are a number of analyses made in the laboratory of the Bureau of Soils of the valley soils of the Colorado River.

Chemical analyses of samples of alkali soils, Yuma area, Arizona.

CONSTITUENTS—IONS.

Laboratory No.	Per cent soluble salts.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Sulphuric acid (SO_4).	Chlorine (Cl).	Bicarbonic acid (HCO_3).	Carbonic acid (CO_3).
10221	0.76	1.31	1.05	26.25	5.77	21.52	22.05	22.05	----------
10223	.48	9.48	3.44	12.50	5.17	34.06	12.07	23.28	----------
10224	.68	2.34	5.26	18.72	2.04	42.98	4.09	24.57	----------
10226	1.09	3.85	.36	26.22	5.87	14.68	33.61	15.41	----------
10227	.93	----------	.64	29.68	2.15	48.61	6.02	12.90	----------
10228	3.57	4.14	.89	30.80	1.68	8.84	50.46	3.19	----------
10229	3.00	1.06	.79	29.57	6.39	18.04	39.36	4.79	----------
10232	3.51	3.87	1.59	25.95	5.81	13.56	46.49	2.73	----------
10233	4.24	8.45	1.79	22.43	5.38	5.28	53.84	2.83	----------
10236	12.96	7.45	2.70	25.11	1.86	4.74	57.59	.55	----------
10238	1 68	3.33	3 56	23.32	4.87	22.00	36.86	6.06	----------
10239	2.63	11.47	3.79	17.16	2.12	15.18	45.96	4.32	----------
10240	.59	4.73	4.39	15.88	7.43	29.73	7.57	20.27	----------
10242	5.31	6.29	.18	26.19	2.63	36.40	26.51	1.80	----------
10244	.53	8.33	5.30	12.50	2.65	40.92	10.60	19.70	----------
10245	.53	8.23	5.24	11.99	3.74	40.46	7.86	22.48	----------
10248	.98	3.49	1.23	23.21	6.57	35.93	17.25	12.32	----------
10249	3.21	4.23	2.53	23.49	7.35	12.03	47.38	2.99	----------
10250	.32	8.80	5.03	13.21	2 51	27.07	13.20	30.18	----------
10251	.93	8.17	4.30	10.33	7.52	35.26	24.10	10.32	----------

Chemical analyses of samples of alkali soils, Yuma area, Arizona—Continued.

CONSTITUENTS—IONS—Continued.

Laboratory No.	Per cent soluble salts.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Sulphuric acid (SO_4).	Chlorine (Cl).	Bicarbonic acid (HCO_3).	Carbonic acid (CO_3).
10253	2.19	3.20	1.46	26.81	6.49	11.53	45.02	5.49	....
10254	3.86	4.25	2.23	24.94	6.74	8.65	50.70	2.49	....
10255	2.09	3.06	.48	24.64	11.61	11.32	43.14	5.75	....
10256	1.07	....	1.49	27.99	8.95	13.80	36.77	6.71	4.29
10257	1.27	4.39	1.25	26.85	3.45	14.44	39.73	9.89	....
10260	4.02	2.73	1.19	30.54	3.77	8.50	51.48	1.79	....
10261	2.99	2.07	.53	30.28	4.28	22.95	36.68	3.21	....
10262	2.42	7.59	1.23	23.68	4.29	15.18	44.07	3.96	....
10263	1.80	....	1.11	30.00	7.11	9.66	43.79	8.33	....
10264	3.67	15.99	3.04	14.65	1.90	6.52	55.13	2.77	....
10265	2.21	1.99	1.08	29.15	5.15	15.75	42.00	4.88	....
10267	1.84	15.34	3.04	8.82	9.46	10.23	47.46	5.65	....
10268	1.98	1.51	.80	29.87	3.54	29.75	28.46	6.07	....
10269	1.00	.80	.80	26.25	10.42	13.02	36.69	12.02	....
10270	2.71	2.07	.59	26.19	7.68	33.62	24.98	4.87	....
10273	1.54	10.36	3.10	15.18	7.38	14.37	41.84	7.77	....
10274	1.08	7.57	2.03	20.71	5.91	13.30	41.61	8.87	....
10275	4.35	6.62	1.79	25.49	2.94	15.09	47.25	.82	....
10277	2.92	.82	.41	33.24	3.55	12.66	45.22	4.10	....
10279	1.12	6.61	2.50	18.61	6.79	31.49	25.42	8.58	....
10285	.93	6.86	1.50	19.53	6.86	22.76	27.04	15.45	....
10289	.39	....	5.61	18.38	4.59	23.47	5.10	42.85	....
10290	.73	3.85	3.30	21.24	4.40	13.50	26.98	26.73	....

CONSTITUENTS—CONVENTIONAL COMBINATIONS.

Laboratory No.	Calcium sulphate ($CaSO_4$).	Calcium chloride ($CaCl_2$).	Magnesium sulphate ($MgSO_4$).	Magnesium chloride ($MgCl_2$).	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na_2SO_4)	Sodium bicarbonate ($NaHCO_3$)	Sodium carbonate (Na_2CO_3)
10221	4.46	....	4.98	....	11.03	27.83	21.25	30.45	....
10223	32.32	....	13.79	3.44	9.92	7.76	....	32.77	....
10224	7.89	....	26.02	....	3.80	3.80	24.57	33.92	....
10226	13.03	....	1.65	....	11.19	46.62	6.23	21.28	....
10227	....	....	3.22	....	4.08	6.66	67.98	18.06	....
10228	12.54	1.23	....	3.52	3.19	75.10	....	4.42	....
10229	3.66	....	3.86	....	12.25	55.26	18.38	6.59	....
10232	13.16	....	5.36	1.99	11.06	64.67	....	3.76	....
10233	7.50	17.24	....	7.03	10.20	54.07	....	3.96	....
10236	6.71	15.15	....	10.59	3.55	63.25	....	.75	....
10238	11.29	....	17.60	....	9.39	53.40	....	8.32	....
10239	21.49	14.28	....	14.88	4.02	39.33	....	6.00	....
10240	15.88	....	21.62	....	14.19	17.91	2.02	28.38	....
10242	21.38	....	.90	....	5.04	39.72	30.48	2.48	....
10244	28.41	....	26.14	....	4.92	13.63	....	26.90	....
10245	28.09	....	25.84	....	7.11	7.49	....	31.47	....
10248	11.91	....	5.95	....	12.52	18.68	33.69	17.25	....
10249	14.40	....	2.33	8.03	14.27	56.83	....	4.11	....
10250	29.56	....	8.17	11.95	4.40	4.40	....	41.52	....
10251	27.74	....	19.35	2.36	14.42	21.94	....	14.19	....
10253	10.88	....	4.85	1.74	12.35	62.50	....	7.68	....
10254	12.24	1.86	....	8.71	12.86	60.91	....	3.42	....
10255	10.35	....	2.30	....	22.05	53.99	3.26	8.05	....

Chemical analyses of samples of alkali soils, Yuma area, Arizona—Continued.

CONSTITUENTS—CONVENTIONAL COMBINATIONS—Continued.

Laboratory No.	Calcium sulphate ($CaSO_4$).	Calcium chloride ($CaCl_2$).	Magnesium sulphate $MgSO_4$).	Magnesium chloride ($MgCl_2$).	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na_2SO_4)	Sodium bicarbonate ($NaHCO_3$)	Sodium carbonate (Na_2CO_3)
10256	....	....	7.09	....	17.16	47.03	12.13	9.14	7.45
10257	14.91	....	4.86	1.25	6.59	58.73	....	13.66	....
10260	9.29	....	2.43	2.73	7.21	75.91	....	2.43	....
10261	7.03	....	2.54	....	8.17	54.20	23.64	4.42	....
10262	21.54	3.38	....	4.86	8.16	56.62	....	5.44	....
10263	....	....	5.33	....	13.56	61.55	8.11	11.45	....
10264	9.24	36.83	....	11.91	3.64	34.58	....	3.80	....
10265	6.79	....	5.34	....	9.86	61.46	9.86	6.69	....
10267	14.47	30.68	....	11.86	18.06	17.21	....	7.72	....
10268	5.16	....	3.84	....	6.78	34.12	41.60	8.50	....
10269	2.80	....	3.80	....	19.84	44.90	11.82	16.84	....
10270	7.02	....	2.80	....	14.63	29.78	39.05	6.72	....
10273	20.33	12.17	....	12.17	13.87	30.57	....	10.89	....
10274	18.86	5.54	....	7.95	11.27	44.18	....	12.20	....
10275	21.34	1.01	....	7.03	5.61	63.86	....	1.15	....
10277	2.87	....	1.98	....	6.77	69.30	13.34	5.74	....
10279	22.57	....	12.16	....	12.88	31.82	8.76	11.81	....
10285	23.17	....	7.29	....	13.09	34.14	1.07	21.24	....
10289	....	....	27.55	....	8.67	2.04	2.55	59.19	....
10290	12.95	....	5.50	8.53	8.26	27.84	....	36.92	....

The alkali of the valley lands is purely a surface accumulation—that is, nearly all the salt is included at least in the surface 6 feet, and in many cases is found only in the first 3 feet. Since its accumulation is due to evaporation from the surface, its presence as a surface accumulation is not strange. In the case of the lands subject to annual overflow, where there is a slight accumulation of alkali after subsidence of the floods, the alkali is wholly a surface accumulation, practically all of it being found in the first inch or so of soil. The areas immediately surrounding present overflow land, which annually have the water table raised near the surface, but have not been flooded for many years, have the alkali distributed through from 1 to 4 feet of the soil, depending upon its texture and the height to which the water table is raised. In the lighter, sandier soils the alkali is nearly all in the surface foot, while in the heavier, slowly penetrable soils the alkali often extends to a depth of 4 or 5 feet.

Along the mesa lands, or below the bluff line, the alkali conditions are not so recent in origin, but have been maintained for a long time, or since the mesa was drained after its elevation above water. The water table here is not at present near the surface, and is not raised annually, so that the alkali has been partly washed into the subsoil, which is quite heavy and readily retains the salts. Here the alkali is usually distributed more evenly throughout the surface 6 feet, and in some instances extends below the sixth foot in noticeable quantities.

Accompanying this report is an alkali map, showing in colors areas containing less than 0.20 per cent, from 0.20 to 0.40 per cent, from 0.40 to 0.60 per cent, from 0.60 to 1 per cent, from 1 to 3 per cent, and more than 3 per cent. This map was constructed from a great many borings and tests made in the field, about one boring to each 40 acres being made in the alkali-affected districts. The map shows the average per cent for the surface 6 feet, while on the classification sheets the percentage for the surface foot is also shown. A comparison of the percentages for the surface foot and the average for the 6 feet will illustrate the greater amount found in the surface.

The following table shows the number of acres and the percentage of the area mapped, covered by each of the grades of alkali soil above mentioned:

Area of different grades of alkali soil.

Grade of soil.	Acres.	Per cent of area.
Less than 0.20 per cent	177,408	81.5
From 0.20 to 0.40 per cent	15,168	6.9
From 0.40 to 0.60 per cent	6,208	2.8
From 0.60 to 1 per cent	5,376	2.5
From 1 to 3 per cent	8,896	4.2
Over 3 per cent	4,352	2.1
Total	217,408	

AGRICULTURAL CONDITIONS.

No farming worthy of the name is being attempted in that part of the valley and delta included in this survey. Immediately below Yuma, however, as already pointed out, in what is known as Yuma Valley, alfalfa, grain, vegetables, corn, sorghum, and in fact all the common field crops, besides deciduous fruits and grapes, have been produced in considerable quantities for a number of years. Corn and other summer crops have also been grown, after the subsidence of the overflow, without irrigation. A few who have tried this farming after the overflow have been quite successful, and no doubt much could be done in this way pending the completion of the irrigation works and dikes. On the mesa land, near Yuma, there is a grove of oranges, a few vines, and some deciduous fruits which do fairly well. This is the Blaisdell tract, mentioned before in the course of this report. Under a high state of cultivation, with plenty of water, such fruits would no doubt prove valuable.

Labor is scarce and quite high. Nearly all the work of the farms is now done by either Mexicans or Indians, who receive from $1 to $1.50 a day, with board in addition.

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MILTON WHITNEY, CHIEF

ALKALI MAP

ARIZONA – CALIFORNIA
YUMA SHEET

Alkali Surveyed by
J. Garnett Holmes, Charles A. Jensen, Herbert W. Marean,
N. P. Neill, Aldert S. Root, W. E. McLendon, J. L. Burgess,
A. T. Strahorn and A. T. Sweet.
1902 – 1904

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Field Operations
Bureau of Soils
1904

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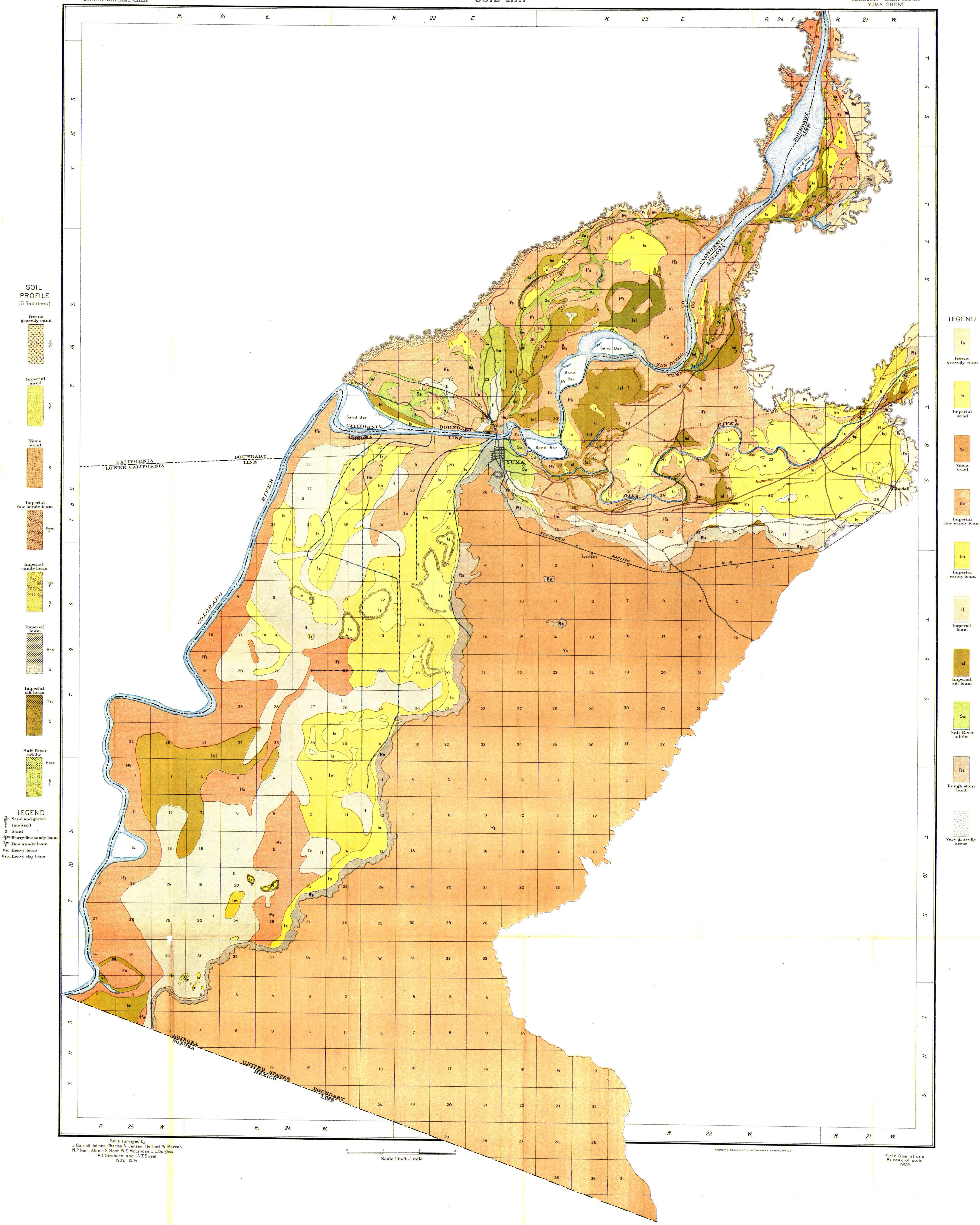
SOIL MAP

ARIZONA - CALIFORNIA
YUMA SHEET



Soils surveyed by
J. Garnett Holmes, Charles A. Jensen, Herbert W. Marean, N.P. Neill, Aldert S. Root, W.E. McLenden, J.L. Burgess, A.T. Strahorn and A.T. Sweet.
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Scale 1 inch = 1 mile

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